1,149,808

PATENT SPECIFICATION

DRAWINGS ATTACHED

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COMPLETE SPECIFICATION

Well Tool

We, SCHLUMBERGER TECHNOLOGY CORPORATION, a corporation organized and existing under the laws of the State of Texas, United States of America, of 277 Park Avenue, New York, New York, United States of America, do hereby declare the invention, for which we pray that a patent may be granted to us and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates generally to well tools and more specifically to well tools for packing off or isolating well bore zones.

The present invention provides a well tool for use in a well bore, comprising a body portion, packing means mounted on the body portion to provide a seal between the body portion and the wall of said well bore, wall engaging members, and expanding means for urging said wall engaging members apart into engagement with said wall, said expanding means having a first surface with which pressure on one side only of said packing means can communicate and a second surface remote from said first surface with which pressure on the other side only of said packing means can communicate, whereby a pressure difference existing in either direction across said packing means causes said expanding means to urge said wall engaging members further apart.

A well tool embodying the invention will now be described by way of example with reference to the accompanying diagrammatic drawings in which:

Figure 1 is a schematic view of a well having well tools positioned therein for isolating a zone in which operations are to be performed;

Figure 2A is a sectional view of the upper portion of an apparatus in accordance with the present invention with parts in relative positions for longitudinal movement in a well conduit;

Figure 2B is a view similar to Figure 2A showing the lower portion of the apparatus of the present invention and forms a lower continuation of Figure 2A;

Figure 3 is a cross section taken on line 3—3 of Fig. 2A;

Figure 4 is a cross section taken on line 4—4 of Fig. 2B;

Figure 5A is a sectional view similar to Figure 2A but with parts in relative positions they occupy when the apparatus is set in the well conduit;

FIGURE 5B is the lower continuation of FIGURE 5A; and

FIGURE 6 is a fragmentary view of an alternative embodiment of an apparatus which embodies principles of the present invention.

Referring now to FIGURE 1, a typical well bore *B* is lined with a conduit or casing *C* and traverses the earth formation *F* to be tested, treated, or stimulated. A zone *Z* of the well bore *B* is isolated by a packer P—1 at the zone's upper end and a bridge plug P—2 at the zone's lower end. A tubing string *T* is connected to the packer P—1 for access to the zone *Z* from the earth's surface. Perforations *S* extend through the casing *C* and into the formation *F* for fluid communication between the zone *Z* and the formation *F*. The packer P—1 can be any conventional device normally used in the art such as that shown in U.S. patent No. 3,020,959 or it can embody the concepts of the present invention as will hereinafter be made apparent with respect to a bridge plug.

Referring now to FIGURES 2A and 2B for details of the tool P—2 characterized as a retrievable bridge plug, apparatus in accordance with the present invention includes a generally tubular body member 10 extending throughout the length of the well tool P—2. The body member 10 has a central bore 11 therethrough which is opened at its lower end by several side ports 12. The upper end of the body member is closed by threadedly attached connector head 13 having J-slots 14 in its periphery for connecting to a conven-

tional retrievable bridge plug overshot O (FIGURE 1). An O-ring or other sealing means can make the threaded connection fluid tight.

A plurality of bypass ports 17 extend laterally through the wall of the body member 10 below the connector head 13. Sealing elements 18 and 19 are received in annular grooves above and below the ports 17. A sleeve valve 20 is slidably disposed on the body member 10 adjacent the ports 17 and is movable between a lower position as shown in FIGURE 2—A where the bypass ports 17 are open, to an upper position where the upper end of the sleeve valve 20 abuts the lower end 21 of the connector head 13. In the upper position, the sleeve valve 20 spans the ports 17 and, in combination with the sealing elements 18 and 19, functions to block fluid flow therethrough. A plurality of spring fingers 22 extend from the lower end of the sleeve valve 20 and have enlarged head portions 23 which are sized to engage an upwardly facing shoulder 24 formed on the body member 10 when the sleeve valve is in its upper position. A predetermined downward force is required to cause outward flexure of the spring fingers 22 and downward movement of the sleeve valve 20. This predetermined resistance to downward movement hold the sleeve valve 20 in its upper, port-closing position.

An intermediate portion of the body member 10 is enlarged to provide a downwardly facing shoulder or abutment 27. The abutment 27 has a bore 28 therein which is sized to slidably receive an annular compression sleeve 29 therein. The lower end of the compression sleeve 29 has an outwardly extending annular flange 30 to provide an upwardly facing abutment. An elastomeric packing means 31 is mounted around the compression sleeve 29 with its ends engaging the abutments 27 and 30. Typical O-ring seals 32 and 33 are positioned between the upper abutment 27 and the compression sleeve 29 and between the compression sleeve 29 and the body 10, respectively, to prevent fluid leakage therebetween.

An annular piston member 36 is slidably received on the body member 10 below the compression sleeve 29 and the packing means 31. An expander cone 37 is attached to the piston member 36 by an annular sleeve 38 which is threadedly coupled to the piston member. A seal element 39 seals the threaded connection 40 and another seal element 41 seals between the inner periphery of the piston member 36 and an outer surface of the body member 10.

The expander sleeve 38 forms an internal annular recess 43 which extends from the upper face 44 in the expander cone 37 to the lower face 45 of the attached piston member 36. The recess 43 slidably receives an annular flange 46 which may be an integral part of the body member 10. A suitable sealing element 47 seals between the outer periphery of the flange 46 and the inner periphery of the sleeve 38 so that a fluid-tight chamber 48 is provided between the upper face of the flange 46 and the lower face 45 of the piston member 36. It will be appreciated that the chamber 48 is variable in volume inasmuch as the piston member 36 and the body member 10 can move relative to ane another.

A tubular cage member 50 is movably mounted on the lower end portion of the body member 10 with its lower end normally engaging an upwardly facing shoulder 51 on the body member. A plurality of radially directed, circumferentially spaced recesses 52 in the cage member 50 receive conventional drag blocks 53 which are urged outwardly by springs 54 to engage the well conduit wall, outward movement of the blocks being limited by tangs 56.

The drag blocks 53 function to retard rotational and longitudinal movement of the cage member 50 within the well conduit C. For the purpose of controlling longitudinal relative movement between the cage member 50 and the body member 10, upper and lower segmental ratchet nuts 57, 58, respectively, are positioned within internal annular recesses 59 and 60 in the cage member 50. The ratchet nuts 57 and 58 are commonly called "dizzy" nuts and have internal teeth which can be selectively engaged with external buttress form teeth 62 and 63 on the body member. The upper body teeth 62 are formed to face downwardly so that when they are engaged with the upper ratchet nut 57, the cage member 50 cannot move upwardly relative to the body member 10. However, the body teeth 62 can be released from the ratchet nut 57 by right-hand rotation. The lower body teeth 63 are formed to face upwardly so that when they are engaged with the lower ratchet nut 58, the body member 10 cannot move upwardly relative to the cage member. As in the case of the upper body teeth 62, however, the lower body teeth 63 can be released from the lower ratchet nut 58 by right-hand rotation. Due to the form of the teeth 62 and 63, it will be appreciated that the upper body teeth 62 can be ratcheted upwardly through the upper ratchet nut 57 and the lower body teeth 63 can be ratcheted downwardly through the lower ratchet nut 58. Projections 64 and 64 on the cage member 50 engage between segments of the ratchet nuts 57 and 58 as shown in FIGURES 2B and 4 so that the ratchet nuts cannot rotate relative to the cage member as the body member 10 is rotated. Resilient bands 66 can be positioned within grooves 67 around the nuts 57 and 58 and function to permit radial expansion of the nuts as the body teeth are ratcheted therethrough, while urging inward contraction.

A plurality of slip segments 70 are carried by the upper end of the cage member 50. The

slip segments 70 can have external wickers or teeth 71 on their peripheries which are adapted to grip the well conduit wall and prevent movement of the well tool in either direction. Also, the slip segments 70 can have inner inclined surfaces 72 which diverge upward and outwardly of the body member 10 and are complementary to outer inclined surfaces 73 on the expander cone 37 in a manner whereby when the expander cone 37 is brought into engagement with the slip segments 70, downward movement of the expander cone 37 relative to the slip segments 70 will cause outward shifting of the slip segments 70 to engage the well conduit wall. The lower end of each slip segment 70 can be provided with a keyed tongue 74 which engages in an inclined groove 75 in the cage member 50 so that the slip segments 70 can be readily moved outwardly. Cantilevered spring members 76 can be attached to the other surfaces of the cage member 50 with their free ends pressing the slip segments 70 toward retracted positions

In accordance with the present invention, that portion of the body member 10 adjacent the packing element 31 has at least one fluid passageway 80 as shown in FIGURES 2 and 3 extending longitudinally from ports 81 and 82 which are in communication with the well annulus above the packing element 31, to port means 83 which is in communication with the lower face 45 of the piston member 36. Thus, it will be apparent that the lower face 45 of the piston member 36 is subject to fluid pressures in the well annulus above the packing element 31 while the upper face 84 of the piston member 36 is subject to fluid pressures in the well annulus below the packing element 31. Accordingly, whenever the packing element is set and fluid pressures below the packing element 31 exceed those of fluids above it, the pressure differential will be effective on the piston differential area A as a force tending to move the expander cone 37 downwardly and thus shift the slip segments 70 into more forceful engagement with the well conduit wall Therefore, an upwardly acting pressure differential, instead of tending to unset the well packer, as in the usual case, will be effective to anchor the well packer P—2 even more firmly in the well conduit. On the other hand, when a downwardly acting pressure differential is exerted on the tool, the higher pressure is communicated into the chamber 48 to act upwardly on the lower face of the piston member 36. However, the pressure is also acting downwardly on the cross-sectional area of the expanded packing element 31 and on the compression sleeve 29 so that the net forces on the expander cone 37 are still directed downwardly to force the slip segments 70 outwardly.

An alternative embodiment of an apparatus which embodies the principles of the present invention is shown in FIGURE 6. An annular floating piston member 86 is slidably received in the recess 43 above the expander cone 37. Suitable seals, for example, O-rings 87 and 88, seal between the inner periphery of the piston member 86 and the outer surface of the body member 10, and between the outer periphery of the piston member 86 and the inner surface of the sleeve 38, respectively. An annular shoulder 89 on the body member 10 limits upward movement of the piston member 86 within the recess 43 and downward movement is stopped by the upper surface 44 of the expander cone 37. If the fluid pressures above packing element 31 are lower than pressures below it, the floating piston member 86 will engage the shoulder 89 on the body member 10. The higher fluid pressures below the packing element 31 will exert downward forces on the piston member 36 which it attached to the expander cone 37 as in the case of the apparatus shown in FIGURES 5A and 5B, thereby increasing the outwardly directed forces which are holding the slip segments 70 engaged with the well conduit wall. Moreover, if the pressures above the packing element 31 are higher, the floating piston member 86 will move downwardly to engage the upper face 44 of the expander cone 37, thereby transmitting forces due to such pressures directly to the expander cone 37. Thus, net forces on the expander cone 37 are directed downwardly as in the case of the embodiment shown in FIGURES 5A and 5B to hold the slips 70 in anchoring positions. However, in the embodiment of FIGURE 6, it will be appreciated that the cone holding forces are even higher inasmuch as the floating piston member 86 can itself transmit downward forces to the expander cone 37.

OPERATION

In operation, the parts are assembled as shown in FIGURES 2A and 2B and lowered in the well conduit C to a location where it is desired to form a pressure bridge, for example, the location of the tool P—2 in FIGURE 1. During lowering, the tubing string T is connected to the connector head 13 by an overshot O and the sleeve valve 20 is in its lower position where the bypass ports 17 are open. Thus, fluids in the well bore can bypass through the tool via the lower ports 12, the body passageway 11 and the bypass ports 17. In this manner, the well tool P—2 can be quickly lowered to setting depth.

During lowering, the upper ratchet nut 57 is in engagement with the upper body threads 62 to prevent upward movement of the cage member 50 relative to the body member 10. The slip segments 70 are pressed inwardly by the springs 76, and, being attached to the cage member, cannot move upwardly to be shifted outwardly by the expander cone 37.

At setting depth, the well tool P—2 is halted and the body member 10 is torqued or turned several turns to the right by manipula-

tion of the tubing string T to release the upper ratchet nut 57 from the upper body threads 62. The cage member 50 will not rotate due to the frictional engagement of the drag blocks 53 with the well conduit wall. Release of the upper ratchet nut 57 permits downward movement of the body member 10 relative to the cage member 50 to move the expander cone 37 behind the slip segments 70. As the expander cone 37 is moved downwardly, the slip segments 70 are cammed outwardly into gripped engagement with the well conduit wall.

When the slip teeth 71 are firmly engaged, the expander cone 37 will not move further downwardly and the piston member 36 prevents further downward movement of the compression sleeve 29. Accordingly, the packing element 31 can be compressed between the upper and lower abutments 27, 30 by further downward movement of the body 10 and expanded into sealing engagement with the well conduit wall as shown in FIGURES 5A and 5B.

As the body member 10 moves downwardly relative to the cage member 50, the lower body threads 63 are ratcheted through the lower ratchet nut 58 and it "traps" the body member in its lowermost position to lock the compression energy in the packing element 31. The overshot O can now be manipulated to a release position relative to the connector head 13 and upward movement of the overshot will automatically move the sleeve valve 20 to its upper, port closing position with the spring fingers 22 engaging the shoulder 24 on the body member 10. The cross-sectional areas encompassed by the seal elements 18 and 19 can be made to be substantially the same so that the sleeve valve 20 is pressure balanced and will not move responsive to differences in fluid pressures below and above the well tool P—2.

The tubing string T is then lifted to position the upper packer P—1 above the formation F and the upper packer is set. If a cement squeeze or other pressure operation is conducted in the zone Z above the well tool P—2, the net forces on the expander cone 37 are directed downwardly, as previously described, causing the slips 70 to tightly grip the well conduit wall. Moreover, if the pressures of the fluids above the well tool P—2 are reduced to values lower than those below the tool, the lower pressures are communicated via the passageway 80 to the chamber 48 below the piston member 36. The higher fluid pressures below the packing element 31 act on the upper face 84 of the piston member 36 and the pressure differences will act on the annular cross-sectional area A as downward forces on the expander cone 37 to hold the slip elements 70 firmly engaged with the well conduit wall.

When it is desired to either retrieve the well tool P—2 to the surface or move to another setting position, the upper packer P—1 is released and the tubing string T lowered to engage the overshot O with the connector head 13. The sleeve valve 20 is automatically moved to its lower position where the bypass ports 17 are open to equalized fluid pressures across the packing element 31 and across the cone holding piston member 36. The body member 10 is then turned several turns to the right to release the lower ratchet nut 58 from engagement with the lower body teeth 63, thereby releasing the body member 10 for upward movement relative to the cage member 50. As the body member is pulled upwardly, the compression on the packing element 31 is released and it will inherently retract. The body flange 46 will engage the piston member 36 to pull the expander cone 37 from behind the slip segments 70, thereby permitting their retraction. As the body member 10 reached the upper limit of its travel relative to the expander cone 37, the upper body teeth 62 will ratchet through the upper ratchet nut 57 to again lock the cage member 50 against upward movement relative to the body member 10, downward movement thereof being prevented by the shoulder 51 on the body member 10. The well tool P—2 is then free for shifting in the well conduit C. It will be appreciated that although the present invention has been illustrated in connection with a bridge plug, the concepts involved are applicable to other well tools such as packers and cement retainers

To conduct testing, remedial, simulation or production operations in a particular zone in a well, the zone can be isolated by well tools which can be positioned in the well bore below and above the zone. The lower tool, commonly called a bridge plug, functions to seal off the entire cross-section of the well bore to isolate the zone from fluids at their hydrostatic pressures which are below the zone. The upper tool, commonly called a packer, functions to seal off the annulus between a tubing string attached to the packer and the well casing to isolate the zone from fluids at their hydrostatic pressures which are above the zone. The tubing string provides a means of access to the isolated zone for fluid flow, testing tools, or for wireline or other instruments which can be lowered threthrough.

For the lower tool in previously proposed arrangements, two general types of bridge plugs have been used. First, a so-called "permanent" bridge plug can be used which has opposed slips and a packing element and once set can only be removed by destruction, that is to say, by drilling it away with a drill bit. Second, a so-called "retrievable" bridge plug can be used which will provide a pressure bridge the same as the permanent type plug but which can be retrieved from the well after use. This type of bridge plug has been popular in the industry for the obvious reason that the tool can be retrieved to the surface without requiring a drilling operation.

Very commonly, a bridge plug is required to hold its position within the well casing even though the pressure differentials acting on it are reversed in direction during a typical operation. For example, if cement slurry is squeezed through casing perforations and into earth formations adjacent the isolated zone, the pressure of fluids above the bridge plug may exceed the pressures of the fluids below it. The pressure difference is effective as a force tending to move the plug downwardly. Accordingly, a typical bridge plug has anchors which hold the tool against downward movement. Then the zone may be "swab" tested, e.g. fluids in the tubing string are lifted out and removed to reduce the hydrostatic pressure in the isolated zone to a value lower than natural formation fluid pressures to induce formation fluid flow into the well bore. When this is done, the pressures of fluids below the bridge plub may exceed the pressures of fluids above it and the pressure difference acts as a force tending to move the bridge plug upwardly. Accordingly, previously proposed bridge plugs have anchors which hold them against upward movement.

Such pressure reversals may also act on the packer which is positioned in the well casing above the zone. During a cement squeeze, fluid pressures below the packer will tend to move it upwardly while during "swab" testing, fluid pressure on the well annulus above the packer will exert downward forces on it. Accordingly, a packer in previously proposed tools may have upper and lower anchor devices to prevent its movement in either direction.

The need for opposed sets of anchors to hold against up or down movement has made such previously proposed tools complex in structure and operation. Added complexity increases the probabilities of malfunction and the cost of maintenance.

Accordingly the embodiment described hereinbefore provides a well tool of the retrievable bridge plug form which has only a single anchor and a single expander, yet which will not move up or down in a well conduit even through pressure differences acting on the plug are reversed from down to up, or vice versa. The embodiment described is therefore less complex in structure and operation and relatively free from malfunction and maintenance problems.

WHAT WE CLAIM IS:—

1. A well tool for use in a well bore, comprising a body portion, packing means mounted on the body portion to provide a seal between the body portion and the wall of said well bore, wall engaging members, and expanding means for urging said wall engaging members apart into engagement with said wall, said expanding means having a first surface with which pressure on one side only of said packing means can communicate and a second surface remote from said first surface with which pressure on the other side only of said packing means can communicate, whereby a pressure difference existing in either direction across said packing means causes said expanding means to urge said wall engaging members further apart.

2. A well tool according to claim 1, wherein said body portion has a fluid passage therein which communicates fluid pressure from said other side of said packing means to the second surface of said expanding means, said expanding means being located on said one side of said packing means.

3. A well tool according to claim 2, wherein said first and second surfaces of said expanding means define an annular piston portion slidable axially along said body portion.

4. A well tool according to claim 3, wherein said body portion includes a flange having a surface which extends substantially parallel to said second surface, and wherein said expanding means includes a skirt member extending from said annular piston portion into slidable sealed engagement with said flange, whereby to provide a sealed chamber with which said fluid passage communicates.

5. A well tool according to any preceding claim wherein said packing means, said body portion and said expanding means tend to move relative to said bore, in response to an excess pressure on said second surface, in a direction whereby said expanding means urges said wall engaging member apart.

6. A well tool according to any one of claims 1 to 4, wherein said expanding means tends to move relative to said packing means and said body portion in response to an excess pressure on said first surface, in a direction whereby to urge said wall engaging members apart.

7. A well tool according to any preceding claim including a compression sleeve mounted between said packing means and said body portion, said sleeve and packing means together having a surface adjacent said first surface, the effective area of said surface of the sleeve and packing means being greater than the effective area of said second surface.

8. A well tool according to claim 5 or to claim 6, wherein said wall engaging members are resiliently mounted on a mounting member, and wherein said mounting member coacts with said body portion by means allowing axial travel of said body portion with respect to the

well bore and said mounting member in said direction only.

9. A well tool substantially as herein described with reference to the accompanying drawings.

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3 SHEETS *This drawing is a reproduction of the Original on a reduced scale*

Sheet 1

Fig. 1

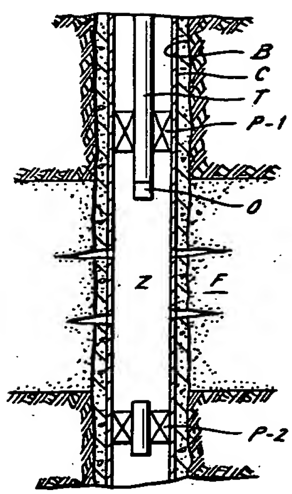


Fig. 3

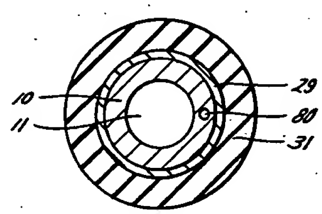


Fig. 4

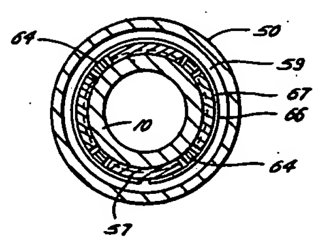
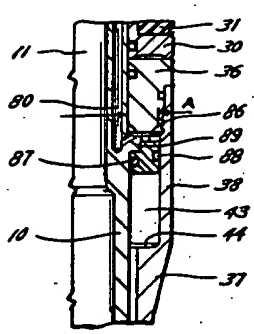


Fig. 6



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1149808 COMPLETE SPECIFICATION

3 SHEETS *This drawing is a reproduction of the Original on a reduced scale*

Sheets 2 & 3

Fig. 2A

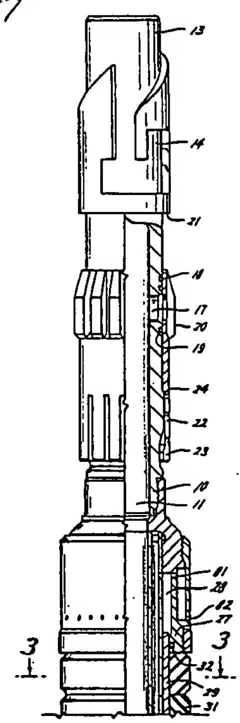


Fig. 2B

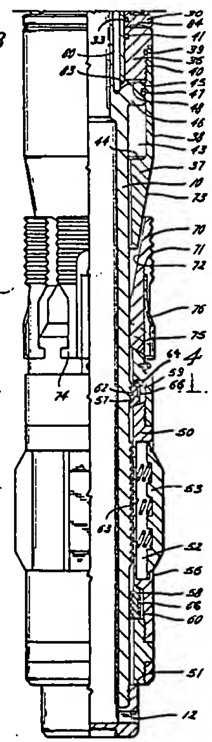


Fig. 5B

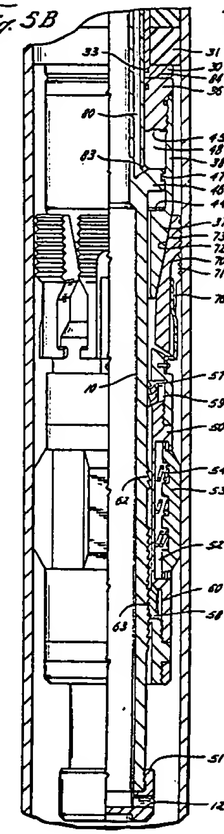
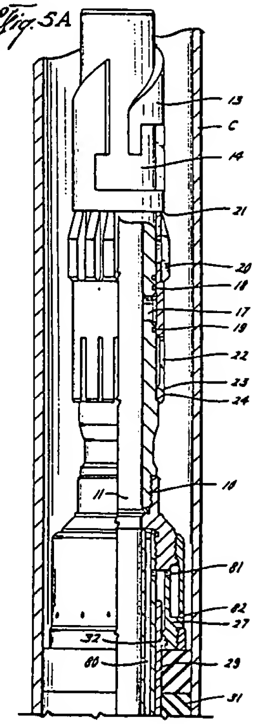


Fig. 5A



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